

New records of *Salmoneus* Holthuis, 1955 (Crustacea: Decapoda: Alpheidae) from northern Australia, with description of one new species and remarks on *S. serratidigitus* (Coutière, 1896)

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ABSTRACT

Saluoneus seticheles sp. nov. is described from the mangroves of Darwin, Northern Territory, Australia. The most characteristic feature of the new species is the presence of long, flexible setae on the upper and lower margins of the major chela. Two individuals possess, instead of a normal minor cheliped, a so-called “subminor” cheliped, which is only slightly smaller than the major cheliped. This type of chelar dimorphism is unique among species of *Saluoneus*. *Saluoneus cristatus* (Coutière, 1897) is reported for the first time from Queensland offshore reefs, representing a further new record for the Australian alpheid fauna. A single, incomplete specimen from Queensland was assigned to the taxonomically problematic *S. serratidigitus* (Coutière, 1896) species complex. At least two species from this species complex are present in northern Australian waters. *Saluoneus latirostris* (Coutière, 1896) and *S. sibogae* (De Man, 1910), prematurely placed in the synonymy of *S. serratidigitus* by Banner and Banner (1981), are considered to be distinct species. A key to world species of *Saluoneus* is provided.

KEYWORDS: Alpheidae, *Saluoneus*, mangroves, coral reef, Northern Territory, Queensland, cheliped dimorphism, species complex, synonymy.

INTRODUCTION

Holthuis (1955) established the alpheid genus *Saluoneus* to replace *Jousseaumea* Coutière, 1896, a junior primary homonym of *Jousseaumea* Sacco, 1894 (incorrect original spelling: *Jousseaumia* Sacco, 1894), a genus of prosobranch molluscs (ICZN, 1963). *Jousseaumea* was erected originally for two species, *Jousseaumea latirostris* Coutière, 1896 and *J. serratidigitus* Coutière, 1896. Holthuis (1955) selected *J. serratidigitus* as the type species of *Saluoneus*, despite the fact that *J. latirostris* has page priority (both species were described on the same page, cf. Coutière 1896: 382).

The genus *Saluoneus* now contains at least 20 species worldwide, most of them in shallow, tropical and warm temperate waters (Chace 1972, 1988; Banner and Banner 1973, 1981; Dworschak *et al.* 2000). In all species the orbital hoods are well developed and completely or partly cover the eyes in dorsal view; the rostrum and the extra-orbital teeth are well developed and acute; the chelipeds are asymmetrical in shape and unequal or subequal in size, with the major chela lacking plunger and fossa (snapping mechanism); the second pleopods bear a well developed appendix masculina and an appendix interna in both sexes; the sixth abdominal somite is devoid of a postero-ventral articulated flap; and the posterior margin of the telson is either truncate or bears a variously shaped median notch (Banner and Banner 1973; Chace 1988; Carvacho 1989).

Only two species, *S. tricristatus* Banner, 1959 and *S. sibogae* (De Man, 1910), have been previously reported from Australian waters (Banner and Banner 1973, 1982; Davie 2002). Subsequently *S. sibogae*, together with *S. latirostris*, were placed in the synonymy of *S. serratidigitus* by Banner and Banner (1981). However, morphological variability of *S. serratidigitus s. lat.* (*sensu* Banner and Banner 1981) and differences in colour pattern (cf. Coutière 1899; Banner and Banner 1981) seem to be beyond intraspecific level, and suggest that both *S. sibogae* and *S. latirostris* are valid species.

During a survey of small benthic organisms on Channel Island near Darwin, Northern Territory in 1991, M. Burke (Museum and Art Gallery of the Northern Territory, Darwin, NTM) collected several alpheid shrimp specimens from muddy substrates of mangrove creeks and river mouths. In the same year, P. Alderslade (NTM) collected a further specimen of the same species from Ludmilla Creek mouth on the other side of Darwin. The shrimps were identified as a new species of *Saluoneus* by Dr. Y. Miya (Nagasaki University) and Dr. A. J. Bruce (in 1991 in the NTM, now associated with Queensland Museum, Brisbane), however, the species has remained undescribed. During my visit to the NTM, in August 2001, I had an opportunity to examine several alpheid specimens, including the specimens from Channel Island. The *Saluoneus* species has been confirmed as new and is described herewith.

The collection of the Museum and Art Gallery of the Northern Territory, Darwin, also contains two other interesting specimens of *Salmoneus* collected on coral reefs off northern Queensland. Despite the imperfect condition of these specimens (both were missing major chelipeds), one has been identified as *S. cristatus* (Coutière, 1897), representing a new record for Australia, and the other is tentatively assigned to *S. aff. serratidigitus*.

Abbreviations used in the text are as following: NTM, Museum and Art Gallery of the Northern Territory, Darwin; MNHN, Muséum National d'Histoire Naturelle, Paris; RMNH, Nationaal Natuurhistorisch Museum, Leiden; USNM, National Museum of Natural History, Smithsonian Institution, Washington D.C.; OUNHM, Oxford University Natural History Museum, Oxford; MCZ, Museum of Comparative Zoology, Harvard University, Cambridge, U.S.A.; NT, Northern Territory; CL, carapace length (in mm), measured from tip of rostrum to posterior margin of carapace; TL, total length (in mm), measured from tip of rostrum to posterior margin of telson.

The holotype and a series of paratypes of the new species are deposited in the collection of the NTM. Additional paratypes are also deposited in other institutions.

SYSTEMATICS

Genus *Salmoneus* Holthuis, 1955

Salmoneus seticheles sp. nov.

Figs 1–5

Type material. HOLOTYPE – 1 female (CL 4.8, TL 14.0), NTM Cr 010571, mouth of Ludmilla Creek, Darwin, NT, 12°24.8' S, 130°51.7' E, LWS, 18 March 1991, hand, P. Alderslade, coll. PARATYPES – 1

female, dissected (CL 5.2, TL 14.8), NTM Cr008266, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 4, 13 July 1991, M. Burke, coll.; 1 ovig. female (CL 5.0, TL 14.5), NTM Cr013580, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 10, 13 July 1991, M. Burke, coll.; 1 ovig. female (CL 4.9, TL 14.2), NTM Cr013581, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 2, 13 July 1991, M. Burke, coll.; 1 young specimen (CL 3.3, TL 10.3), NTM Cr013582, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 9, 13 July 1991, M. Burke, coll.; 1 female (CL 5.0, TL 14.8), NTM Cr013583, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 2, 13 July 1991, M. Burke, coll.; 1 female (CL 4.8, TL 13.9), NTM Cr013584, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 9, 13 July 1991, M. Burke, coll.; 1 ovig. female (CL 5.5, TL 15.4), NTM Cr013585, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 3, 13 July 1991, M. Burke, coll.; 1 specimen (CL 4.8, TL 14.0), NTM Cr013586, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 6, 13 July 1991, M. Burke, coll.; 1 specimen (CL 4.2, TL 12.0), NTM Cr008276, Blackmore River mouth, Channel Island, Darwin, NT, Site 2, Patch B, Quadrat 3, 12°37.3' S, 130°56.6' E, LWS, 13 June 1991, M. Burke, coll.; 1 specimen (CL 4.7, TL 13.8), NTM Cr008277, Blackmore River mouth, Channel Island, Darwin, NT, Site 2, Patch B, Quadrat 2, 12°37.3' S, 130°56.6' E, LWS, 13 June 1991, M. Burke, coll. (specimen parasitized by a bopyrid, latter removed, NTM Cr008574); 1 specimen, possibly female (CL 4.0, TL not measured), USNM 1005100, mouth of Blackmore River, Channel Island, Darwin, NT, Site 2, Patch B, Quadrat 8, 12°37.3' S, 130°56.6' E, LWS, 4 November 1991, M. Burke, coll.; 1 ovig. female (CL 4.7, TL not measured), MNHN–Na 13765, mouth of Blackmore River, Channel Island, Darwin, NT, Site 2, Patch B, Quadrat 10, 12°37.3' S, 130°56.6' E, LWS, 4 November

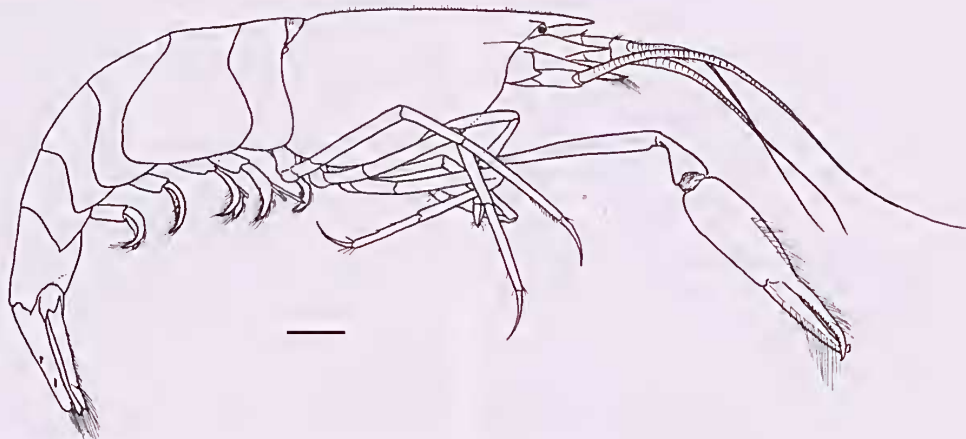


Fig. 1. *Salmoneus seticheles* sp. nov. Holotype NTM Cr010571, female, habitus. Scale: 1 mm.

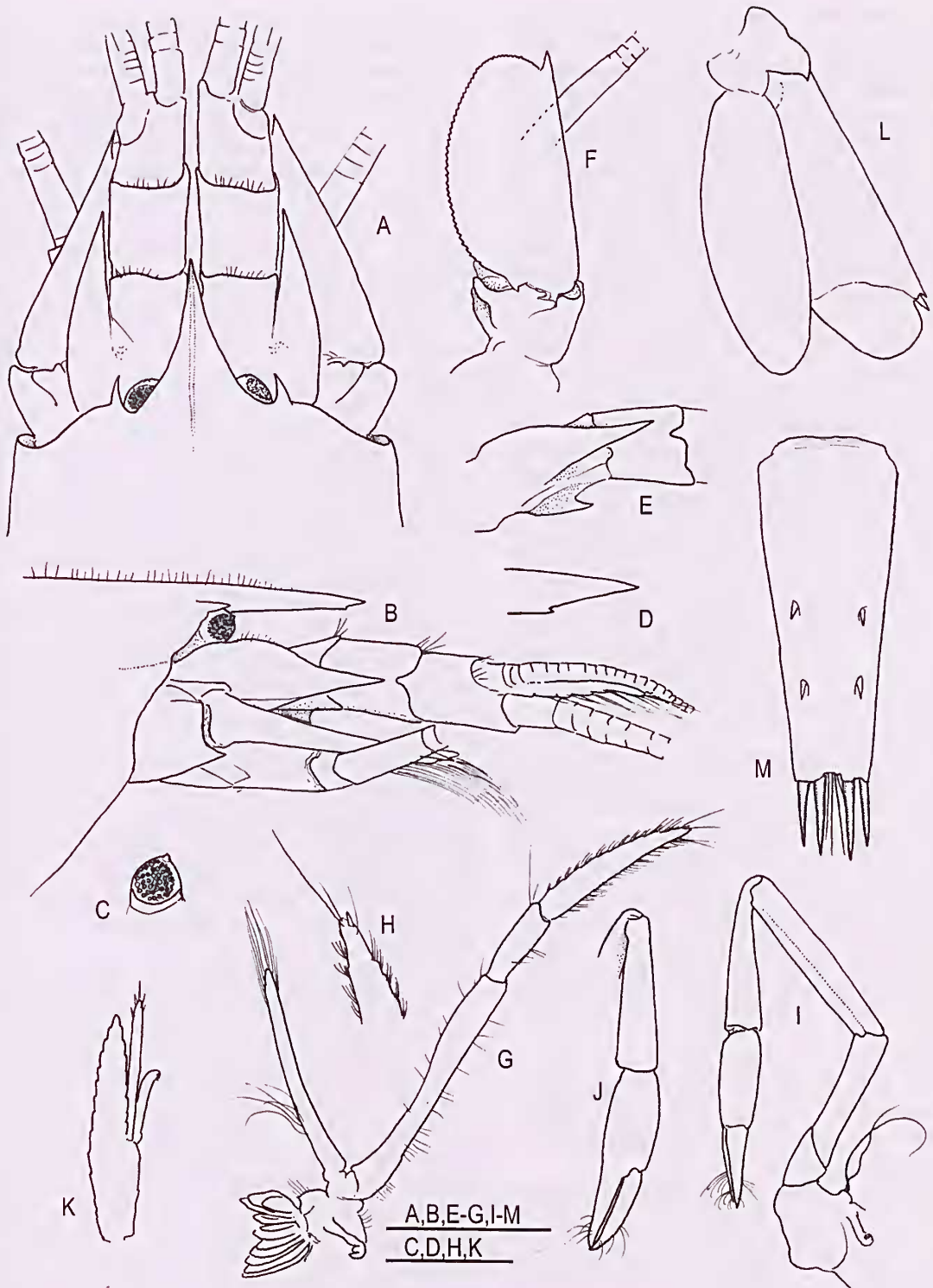


Fig. 2. *Salmoneus seticheles* sp. nov. Holotype NTM Cr010571, female: A, frontal region, dorsal view; B, same, lateral view; C, eyestalk; D, distal rostrum, detail. Paratype NTM Cr008266, female; E, antennule, detail of first and second articles, lateral view; F, antenna; G, third maxilliped; H, same, distal ultimate segment; I, minor cheliped, lateral view; J, same, carpus and chela, mesial view; K, second pleopod; L, uropod; M, telson. Scales: upper scale: 1 mm, lower scale: 0.5 mm.

1991, M. Burke, coll.; 1 specimen, possibly female (CL 4.9, TL not measured), OUMNH Zoo 2002-19-0001, mouth of Blackmore River, Channel Island, Darwin, NT, Site 2, Patch A, Quadrat 3, 12°37.3' S, 130°56.6' E, LWS, 04 November 1991, M. Burke, coll.; 1 specimen, possibly female (CL 4.5, TL not measured), RMNH D 50012, mouth of Blackmore River, Channel Island, Darwin, NT, Site 2, Patch A, Quadrat 3, 12°37.3' S, 130°56.6' E, LWS, 4 November 1991, M. Burke, coll.; 1 adult male [?] (CL 4.9, TL 14.1), NTM Cr013587, Channel Island, Darwin, NT, Site 3, Patch E, Quadrat 6, 13 July 1991, M. Burke, coll.; 1 adult male [?] (CL 4.6, TL *ca* 13.9), MNHN-Na 13693, mouth of Blackmore River, Channel Island, Darwin, NT, Site 2, Patch B, Quadrat 10, 12°37.3' S, 130°56.6' E, LWS, 4 November 1991, M. Burke, coll.

Description. Small-sized alpheid (largest specimens reaching 14.8 mm TL). Carapace covered with fine, erect setae (Fig. 2B). Rostrum broad at base, reaching distal margin of first article of antennular peduncle or slightly beyond it, with a small, but distinct subapical tooth (Fig. 2D); rostral carina feebly developed. Orbital teeth well developed, acute, slightly curved mesially. Eyes partly visible dorsally between orbital teeth and base of rostrum, partly exposed laterally (Fig. 2B), with tiny tubercle on anterior surface (Fig. 2C); cornea well developed, but not occupying entire distal surface of eye peduncle. Pterygostomial angle rounded.

Antennular peduncle robust, second article shorter than visible portion of first article; stylocerite acute, reaching to about 1/2–3/4 length of second article; antennular ventral carina bearing strong, acute tooth (Fig. 2E); outer flagellum subdivided almost at base, aesthetasc-bearing ramus well developed, consisting of at least five articles. Antenna robust, basicerite with strong ventro-lateral tooth; carpocerite short and robust, reaching beyond mid-length of scaphocerite and only to distal end of first article of antennular peduncle; scaphocerite broad, oval (Fig. 2F), with strong disto-lateral tooth, not overreaching distal end of antennular peduncle.

Mouthparts typical for *Salmoneus* and most Alpheidae. Third maxilliped slender; tip with small subterminal spinule (Fig. 2H); coxa with ear-shaped lateral plate and strap-like epipod; arthrobranch present, well-developed (Fig. 2G).

First pereopods or chelipeds asymmetrical in shape and unequal in size, and dimorphic, most specimens bearing a major cheliped and a much smaller minor cheliped (with 50/50 percentage of handedness) characteristic of many other species of *Salmoneus*; two specimens bearing a major cheliped and only a slightly smaller, differently shaped and armed "subminor cheliped".

Major cheliped (Figs 3A–C, 4A) with ischium and merus slender, unarmed, slightly flattened on inner

surface; carpus short, cup-shaped (Fig. 3A); chela almost rounded in cross-section, slightly depressed; palm approximately as long as fingers, smooth except for deep proximal depression at articulation with carpus (Figs 3C, 4A); pollex and dactylus very slightly curved medially (Fig. 3A), almost straight in lateral view except for crossing tips (Fig. 3B); lower margin of distal portion of palm and pollex, and upper margin of dactylus furnished with row of long, fine setae (Figs 3B, 4A); cutting edges each bearing 15–18 rounded teeth (Figs 3B, 4A).

Minor cheliped (Fig. 2I, J) much smaller than major cheliped, with carpus subequal to ischium, and merus approximately 1.2–1.3 times longer than carpus; chela simple, unarmed. Subminor cheliped (Fig. 4B) only slightly shorter than major cheliped (Fig. 5), but much larger and stouter than minor cheliped, with palm being at least 1.5 times longer than pollex, latter distinctly shorter than dactylus (Fig. 4B); cutting edges armed with two larger rounded teeth, much larger than those of major cheliped; lower margins of propodus and dactylus furnished with long, fine, simple (not setulose) setae as in major cheliped (cf. Figs 4A and 4B).

Second pereopod (Fig. 3D) slender; merus 1.5 times longer than ischium; carpus five-jointed, first joint longer than four others combined; chela simple. Third pereopod (Fig. 3E) slender; ischium armed with two spines; merus unarmed; carpus with slender distal spinule or spine-like seta; propodus with four small spines or paired spines, distal spines longest; dactylus very slender and curved, more than 1/2 length of propodus; fourth pereopod similar to third pereopod; fifth pereopod with much longer carpus and propodus (Fig. 3F); propodus armed only with one small spine and pair of apical spines; propodal grooming brush well developed, with about 12 rows of short stiff setae (Fig. 3G).

Abdomen somewhat elongate (Fig. 1); first to fourth segments rounded, fourth segment with postero-ventral margin slightly angular; fifth segment with postero-ventral margin pointed; sixth segment without distinct articulated flap; pre-anal plate rounded and medially depressed. Second pleopod of all specimens examined (including ovigerous females) with appendix interna and appendix masculina, latter twice as long as former and exceeding endopod (Fig. 2K). Uropod with exopod bearing straight diaeresis and short disto-lateral spine (Fig. 2L). Telson sub-rectangular (Fig. 2M), tapering distally, with two pairs of dorsal spines, first and second pair situated at about 1/2 and posterior 3/4 of telson length, respectively; posterior margin truncate, with shallow rectangular median notch, four setae arising from median notch, and two pairs of strong postero-lateral spines (inner spines slightly longer than outer spines, Fig. 2M); anal tubercles absent. Ovigerous

specimens with eggs large, oval (about 0.8 x 0.6 mm diameter) and not numerous (usually less than 20).

Gill formula typical for genus: pleurobranchs above first to fifth pereopods; podobranch absent; one arthrobranch associated with third maxilliped; strap-like epipods (mastigobranchs) on coxae of third maxilliped to fourth pereopod; setobranchs on coxae of first to fifth pereopods; exopods on first to third maxilliped.

Colour in life. Unknown.

Distribution and habitat. Presently known only from Ludmilla Creek (type locality) and Channel Island,

Darwin, Northern Territory, Australia; mud bottom in mangrove forests.

Etymology. The specific name refers to the diagnostic long setae fringing the lower and the upper margins of the major chela.

Remarks. The genus *Salmoneus* can be divided in two species groups, the smaller *S. jarli* (Holthuis, 1951) species group and the larger *S. serratidigitus* (Coutière, 1896) species group. The four species of the *S. jarli* group are all found in the eastern Atlantic Ocean from the Mediterranean Sea to the Cape Verde Islands (Holthuis 1951; Fransen 1991; Dworschak *et al.* 2000).

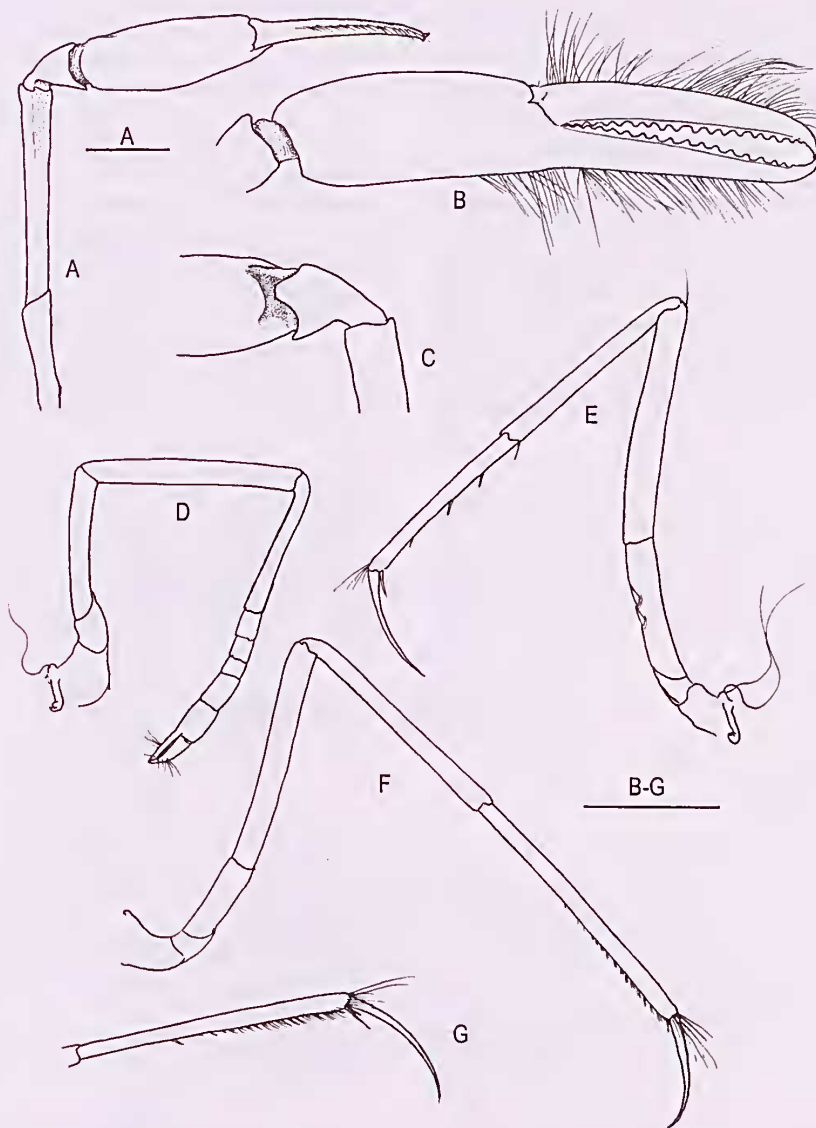


Fig. 3. *Salmoneus seticheles* sp. nov. Paratype NTM Cr008266, female: A, major cheliped; B, same, chela; C, same, distal merus, carpus and proximal palm, ventral view; D, second pereopod; E, third pereopod; F, fifth pereopod; G, same, propodus and dactylus. Scales: 1 mm.

These species are characterized by the slender (minor) cheliped being longer than the stout (major) cheliped. In contrast, all species of the *S. serratidigitus* group are characterized by the minor cheliped being much smaller and less robust than the major cheliped. The 16 species of this group are distributed in the Indo-Pacific from the Red Sea to the Gulf of California (Banner and Banner 1981), as well as in the Western Atlantic from Florida to Brazil (Chace 1972; Christoffersen 1982; Felder and Manning 1986; Holthuis 1990) and Ascension Island in the central Atlantic (Manning and Chace 1990).

Salmoneus seticheles is assigned to the *S. serratidigitus* species group. However, because of the polymorphism of the chelipeds the new species occupies a somewhat isolated position within this group. Most specimens of *S. seticheles* have a major cheliped and a much smaller minor cheliped, which is typical of the *S. serratidigitus* group. A few paratypes have only the major cheliped (the other cheliped could be either minor or subminor), or only the minor cheliped (the opposite cheliped obviously would be major). The remaining two specimens have a major cheliped and a subminor cheliped, and in one of these two specimens (MNHN-Na 13693), both chelipeds are still attached to the body (Fig. 5). The subminor cheliped is only slightly smaller than the major cheliped and differs from the latter by the proportions of the chela, and more

importantly, by the fingers not being serrated with small teeth, as in the major cheliped, but instead, armed with a few much larger teeth. The subminor cheliped is very different from the minor cheliped in being much more robust, with the chela enlarged and armed with teeth (cf. Figs 2I and 4B). Since the major cheliped of specimens with the typical minor cheliped and those with the subminor cheliped is almost identical, the subminor cheliped must be homologous with the minor cheliped.

The completely different shape and size of the minor cheliped could be an indication that two different species are involved. However, in this case there are several reasons to consider that the two specimens with the subminor cheliped belong to *S. seticheles*. With the exception of the subminor cheliped they present no substantial morphological differences to the specimens bearing typical minor chelipeds. The chela of the subminor cheliped is furnished with the similar, long and flexible setae as are found on the chela of the major cheliped (Fig. 4). Furthermore, the two specimens with the subminor cheliped were collected at the same localities as all the other specimens.

The nature of the unusual cheliped polymorphism in *S. seticheles* is unknown, but it is not impossible that the smaller cheliped is sexually dimorphic in this species, a feature not uncommon in the Alpheidae. In this hypothesis, the ovigerous and the non-ovigerous

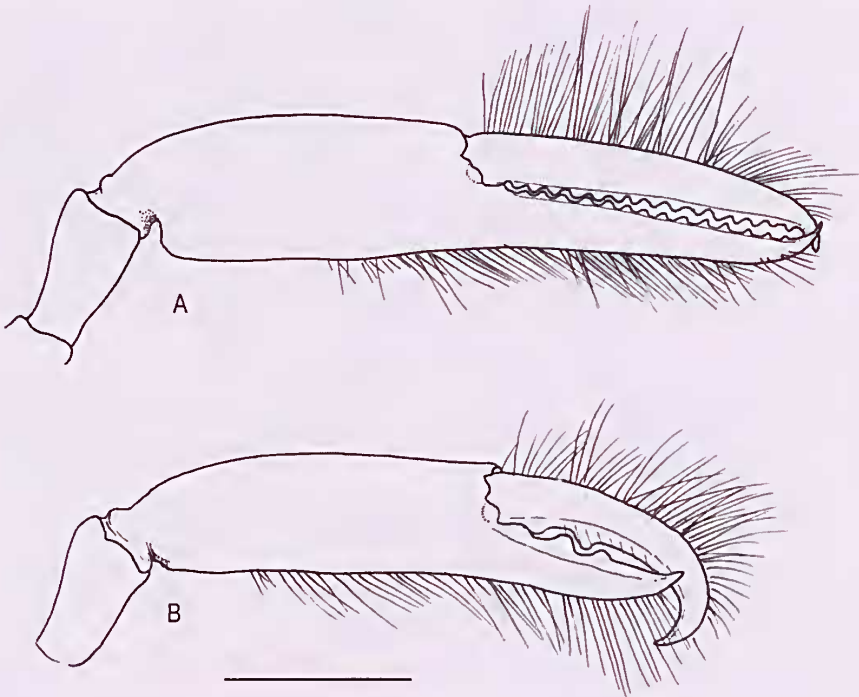


Fig. 4. *Salmoneus seticheles* sp. nov. Paratype NTM Cr013580, ovigerous female: A, major cheliped, carpus and chela. Paratype NTM Cr013587, possibly male: B, subminor cheliped, carpus and chela. Scale: 1 mm.

specimens with a typical minor cheliped are females, and the two non-ovigerous specimens with a subminor cheliped are males. The presence of a well developed appendix masculina in both sexes in all species of *Salmoneus* (Carvalho 1989) prevents this feature being used to sex the non-ovigerous individuals. Another external feature, which is sometimes used to determine the sexes in caridean shrimps, is the shape of the abdominal pleurae. This, however, is similar between the males and the females in all species of *Salmoneus*, and does not permit a clear separation of the sexes. The position of the gonopores on the basis of coxae of third and fifth pereopod (female and male, respectively), cannot be ascertained due to the small size of shrimps. Therefore, the assumption that in the new species the smaller cheliped is sexually dimorphic (minor cheliped in females, subminor cheliped in males) remains tentative.

Within the *S. serratidigitus* group, *S. seticheles* appears to be closest to *S. tafaongae* Banner and Banner, 1966, from Samoa. Banner and Banner (1966a) described *S. tafaongae* on the basis of a single, fragmentary specimen lacking first pereopods, and did not provide figures to illustrate the most important characters of this species. The authors also noted that "it was unfortunate that this single specimen was not more nearly intact, and that the small chela and second legs were lost after the initial examination". In this condition the holotype of *S. tafaongae* is difficult to use for comparison with other species (except for the frontal region). Further, the holotype was not located in the collections of the Bernice P. Bishop Museum, Honolulu, or the National Museum of Natural History, Smithsonian Institution, Washington, D.C., where it was probably deposited. Nevertheless, the poor original

description of *S. tafaongae* provides enough information to discriminate *S. seticheles* from *S. tafaongae*. In both species the corneas are dorsally exposed between the orbital teeth and the base of the rostrum; the rostrum bears a small subterminal tooth on the inferior margin; the posterior margin of the telson bears a shallow trapeziform cleft; and the third to fifth pereopods are slender and have a long, slender daetylus. However, in *S. tafaongae* the rostrum is three times as long as broad at its base and reaches to the end of antennular peduncle, while in *S. seticheles* the rostrum is approximately 1.5 times as long as broad and reaches slightly beyond the distal margin of the first antennular article. The ratio of articles of the minor cheliped from ischium to daetylus was noted as 10: 10: 11: 10: 3 in *S. tafaongae* (carpus longest) while *S. seticheles* presents a ratio equal to about 10: 18: 10: 10: 4 (merus longest, Fig. 3D). Also, the spines on the posterior margin of telson appear to be shorter, only 1.2 versus 1.6 times as long as the width of the posterior margin. In *S. tafaongae* the extra-corneal teeth (erroneously called "supra-corneal spines") are upturned, while in the new species they are not. Finally, the holotype of *S. tafaongae* was collected on the "outer portion of fringing reef, shoreward of surf zone, about one ft [0.3 m] below low water" (Banner and Banner 1966a), while the type series of *S. seticheles* was collected at low tide in soft muddy substrates of the mangroves.

Only five other *Salmoneus* species have partly exposed eyes in the dorsal view, but none of them has the major chela furnished with the elongate, flexible setae, as in *S. seticheles*. *Salmoneus gracilipes* Miya, 1972, can be separated from the new species by the longer stylocerite, more robust major chela, and less

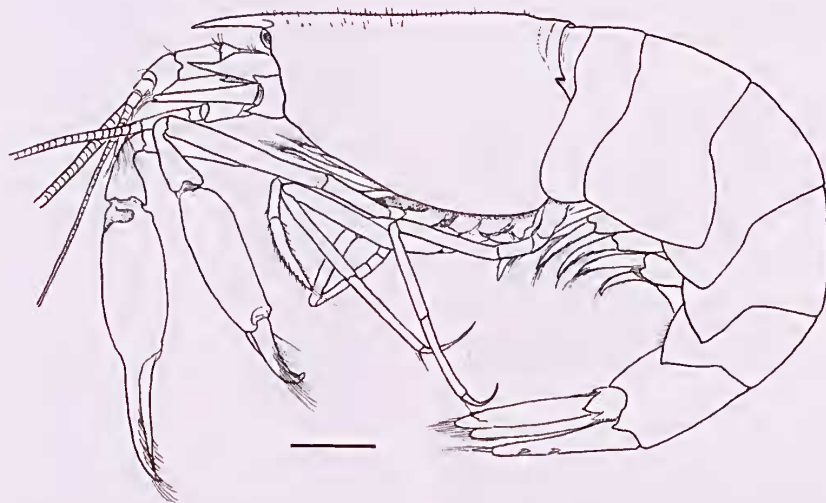


Fig. 5. *Salmoneus seticheles* sp. nov. Paratype MNHN-Na 13693, possibly male. Habitus.

slender dactylus of the third to fifth pereopods (Miya 1972: pl. 3). *Salmoneus latirostris* (Coutière, 1896) is different from *S. seticheles* in several features, including the frontal margin and the more robust and much shorter dactylus of the third pereopod (Coutière 1899). The other species of *Salmoneus* having partly exposed eyes, *S. bruni* Banner and Banner 1966, *S. rostratus* Barnard, 1962 and *S. singaporensis* Anker, in press, have very different major chelipeds (Barnard 1962; Banner and Banner 1966b; De Grave and Wilkins 1997; Anker in press), and are not closely related to *S. seticheles*. Among the species characterized by the eyes concealed in dorsal view, none have the third to fifth pereopods with a long, slender dactylus, and the major chela fringed with long, flexible setae.

Bruce and Coombes (1997) reported an unidentified species of *Salmoneus* from Bullocky Point and Darwin Harbour under the name "*Salmoneus* sp. nov. ? (*cf. tafaongae* ?)", and added that the specimens were "currently under study by Dr Y. Miya". The identity of these specimens remains unknown; they could belong to *S. seticheles* or to another species. No specimens from Bullocky Point are present in the material described here as *S. seticheles*.

Salmoneus cristatus (Coutière, 1897)

Fig. 6

Jousseamea cristata Coutière, 1897: 234; Coutière 1898: 40; Coutière 1899: 71, fig. 22 (see Chace and Forest 1970 for all page numbers).

Salmoneus cristatus (Coutière). – Holthuis 1958: 18, fig. 7; Banner and Banner 1966b: 40, fig. 10; Johnson 1976: 42; Bruce 1976: 44; Banner and Banner 1981: 54, fig. 6; Banner and Banner 1983: 88.

Material examined. 1 ovigerous female (CL 5.9 mm), major cheliped missing, NTM Cr010678, MV *NJoy* anchorage, Ashmore Reef, Coral Sea, Queensland, Australia, 10° 26.66' S 144° 26.82' E, HL 93–9, surface, 16 January 1993, night light, H.K. Larson *et al.* coll.

Remarks. Although the specimen from the Coral Sea (Fig. 6) is missing its major cheliped, there is little doubt that it belongs to *S. cristatus*. Especially characteristic for this species is the sharp rostral carina followed by a mid-dorsal carina not reaching the posterior margin of the carapace (Fig. 6A). *Salmoneus cristatus* is one of the better known *Salmoneus* species, with descriptions and figures published by Coutière (1899), Holthuis (1958) and Banner and Banner (1966b, 1981). Coutière (1899) described the colour pattern of *S. cristatus* as semi-transparent with red transverse bands; a more detailed colour description was provided by Holthuis in Banner and Banner (1981).

The opportunity is taken here to add some rarely observed but potentially interesting features to the previous descriptions of this species. These features

could be valuable for taxonomy and phylogeny of the genus *Salmoneus*. The third maxilliped of *S. cristatus* appears to be typical for *Salmoneus* in that the coxal lateral plate above the strap-like epipod is oval-rounded in shape, not produced (Fig. 6E), while the tip of the ultimate segment is armed with two or three small spines. The appendix masculina on the second pleopod only slightly exceeds the appendix interna. The pre-anal plate of the sixth abdominal segment is posteriorly produced, but distally rounded, not pointed, as in some other species of the genus.

Salmoneus cristatus has been previously reported from the Indian Ocean, including the Red Sea (Holthuis 1958; Banner and Banner 1981), Djibouti, Gulf of Aden – the type locality (Coutière 1897, 1899), Kenya, Madagascar, Seychelles (Bruce 1976; Banner and Banner 1983), and Phuket, Thailand (Banner and Banner 1966b). This record considerably extends the range of this species to north-eastern Australia and, for the first time, from the Indian Ocean to the Pacific Ocean.

Salmoneus aff. *serratidigitus* (Coutière, 1896)

Fig. 7

Material examined. 1 ovigerous female, (CL 4.9 mm), major cheliped missing, NTM Cr008975, SE Cape York Peninsula, Coral Sea off Queensland, 11°37.6' S 142°58.2' E, Station 77, beam trawl, 15 m, from sponge, 1 December 1991, A.J. Bruce and R. Williams, coll.

Description. The most important diagnostic features of this incomplete specimen are as following: rostrum as long as broad at its base, reaching almost to distal margin of second article of antennular peduncle (Fig. 7A); lateral margin concave in dorsal view, dorsal carina feebly developed (Fig. 7A); orbital teeth small, acute (Fig. 7B); eyes completely concealed in dorsal view, anterior portion visible in lateral view (Fig. 7B); stylocerite reaching to rostral tip and nearly to distal margin of second article of antennular peduncle; minor cheliped with carpus slightly shorter than merus (Fig. 7C); carpus of second pereopod five-jointed, with ratio: 10: 3: 1.5: 2: 4 (Fig. 7D); third pereopod with two spines on ischium, dactylus less than half as long as propodus (Fig. 7E); pre-anal plate rounded, not produced; posterior margin of telson with deep median cleft (Fig. 7F), inner posterior spines twice as long as outer spines, and 1/5 longer than width of posterior margin. Field notes indicate that the colour was "yellowish, ova bright orange, antennae also bright orange, antennules less", and that the specimen was collected from a sponge trawled from 15 m.

Remarks. The specific identity of this incomplete female cannot be determined without the major cheliped. It belongs most probably to the *Salmoneus serratidigitus* species complex, which includes

S. serratidigitus and two other nominal species, *S. sibogae* and *S. latirostris*, placed in the synonymy of *S. serratidigitus* by Banner and Banner (1981). *Salmoneus* sp. aff. *serratidigitus* appears to be close to *S. latirostris* in the shape of the rostrum and extra-corneal teeth (cf. Fig. 6 and Coutière 1899: 71, fig. 21), and differs from the neotype of *S. serratidigitus* from Djibouti, as redescribed and refigured by Banner and Banner (1981), and from *S. sibogae*, as illustrated by De Man (1915), in the shape of the rostrum, and

also in having a shorter stylocerite and deeper postero-medial cleft on the telson. However, the uniform yellow colour of the present specimen suggests that it cannot belong to *S. latirostris*, which has bright red transverse bands across the carapace and the abdomen (Coutière 1899; Holthuis 1958). On the other hand, the colour pattern of this incomplete specimen is similar to the patterns described for *S. serratidigitus* and *S. sibogae*. The colour of *S. serratidigitus* was described as uniform yellow-

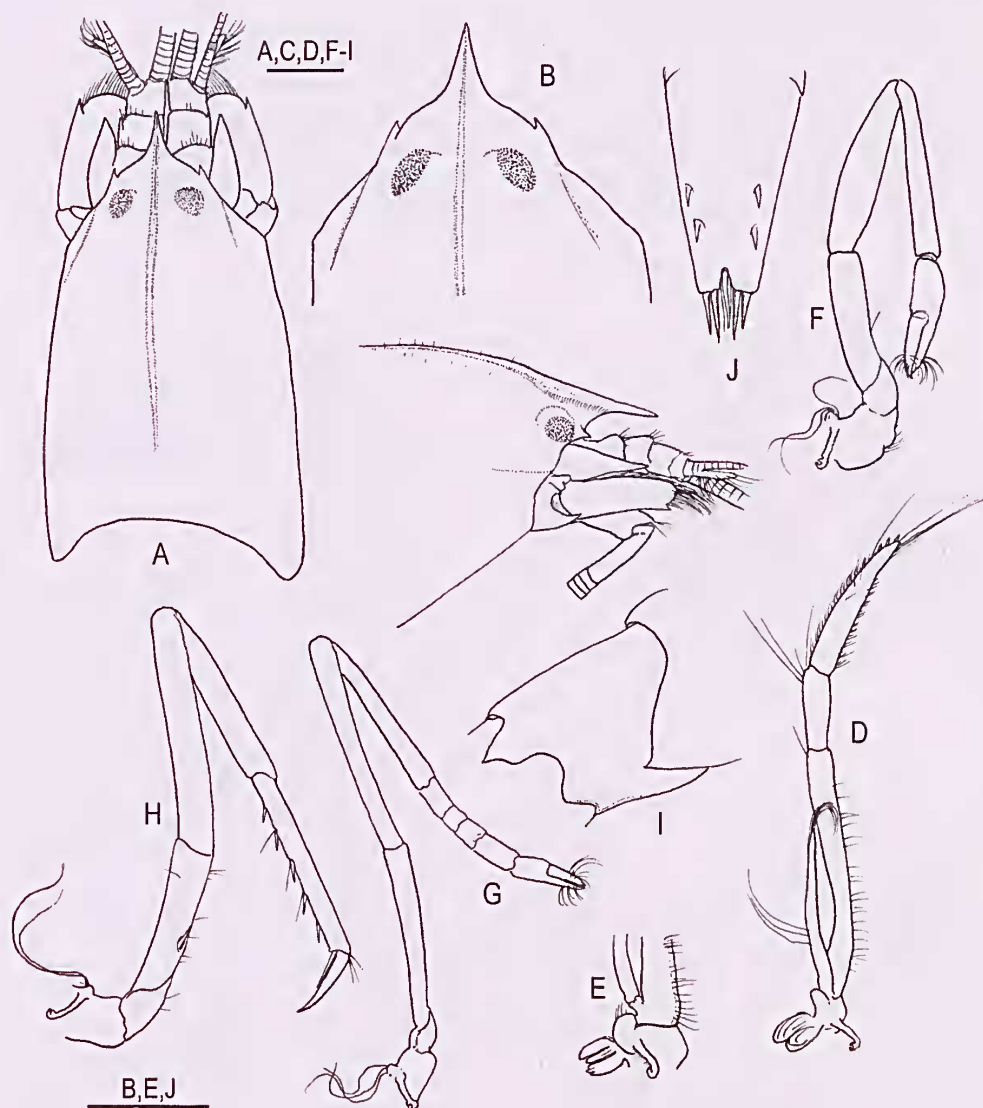


Fig. 6. *Salmoneus cristatus* (Coutière, 1897). NTM Cr010768, ovigerous female from Ashmore Reef, Queensland: A, carapace and frontal region, dorsal view; B, frontal margin, dorsal view; C, same, lateral view; D, third maxilliped; E, same, different aspect of basal portion; F, minor cheliped; G, second pereopod; H, third pereopod; I, posterior margin of fifth and sixth abdominal segments; J, telson. Scales: 1 mm.

orange by Coutière (1899), and “yellow or bright yellow, one specimen with orange-red viscera showing through the carapace, another specimen uncolored, with eggs and gonads orange” by Holthuis in Banner and Banner (1981). The colour of *S. sibogae* was described as “translucent white with an orange liver [digestive gland]” (Banner and Banner 1982) or “bright yellow to muddy white, eggs red” (Banner and Banner 1968). However, most other *Salmoneus* species also have uniformly yellow or creamy-whitish coloration (e.g., Edmondson 1930; Ríos 1992; Dworschak *et al.* 2000).

Salmoneus serratidigitus was very briefly described by Coutière (1896) from the Red Sea, and subsequently reported from the Red Sea (Banner and Banner 1981), Gulf of Aden (Coutière 1899), East Africa, Madagascar, Seychelles (Banner and Banner 1983), Indonesia (Banner and Banner 1985), Hong Kong (Bruce 1992), Japan (Hayashi 1995; Nomura *et al.* 1998), Micronesia (Miya 1984), Kiribati (Hayashi 1995), Galapagos (Wicksten 1993) and Gulf of California (Wicksten

1983). *Salmoneus latirostris* was originally described from the Red Sea (Coutière 1896), and was reported only from Djibouti in the Gulf of Aden (Coutière 1899). *Salmoneus sibogae* was originally described from Indonesia (De Man 1910, 1911, 1915), and subsequently found in the Red Sea (Holthuis 1958), Hong Kong, Philippines (Banner and Banner 1978), Australia (Banner and Banner 1982), Micronesia, Kiribati, Fiji and French Polynesia (Banner and Banner 1964, 1966a, 1967, 1968).

The type of *S. serratidigitus* from the Red Sea could not be located in the MNHN, but a specimen labelled “*Jousseamea serratidigitus* (H. Coutière – type) Muséum Paris, Djibouti H. Coutière 109–97”, was found in the collection of the Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts (Banner and Banner 1981). Coutière’s handwriting on the label suggests that it was personally identified by him. This specimen (MCZ 5556) was designated as the neotype of *S. serratidigitus*, and

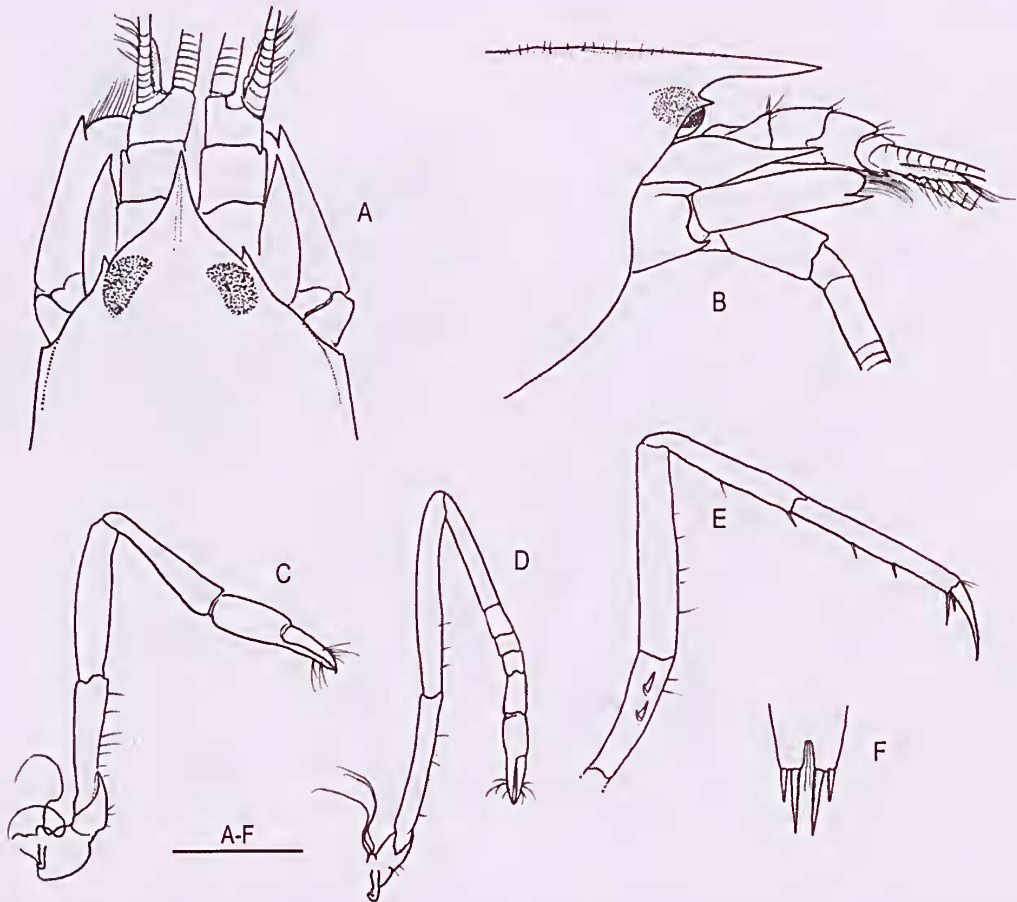


Fig. 7. *Salmones* sp. aff. *serratidigitus* (Coutière, 1896). NTM Cr008975, ovigerous female from off SE Cape York, Queensland. A, frontal region, dorsal view; B, same, lateral view; C, minor cheliped; D, second pereopod; E, third pereopod; F, telson, posterior margin. Scale: 1 mm.

described and illustrated by Banner and Banner (1981). The holotype of *S. latirostris* from the Red Sea, which according to the inadequately brief description by Coutière (1896) was missing the major cheliped, could not be located in the MNHN. Later Coutière (1899) provided several figures of *S. latirostris*, and noted that the chela of this species was generally similar to that of *S. serratidigitus*, but was more regularly oval and lacking the deep groove on the palm. The "type" of *S. latirostris* from Djibouti, registered under the number MNHN-Na 2781, was found to be *S. cristatus* (see discussion in Banner and Banner 1981). The location of the type of *S. sibogae* remains unknown (Banner and Banner 1981).

Banner and Banner (1981) examined about 20 specimens of *S. serratidigitus* from different localities, including the Red Sea, Madagascar and Gulf of California. They found that the species "show a wide range of variation in characteristics that have been used previously for separation of the species" (e.g., shape and length of rostrum, proportions of some articles in the first, second and third pereopods, presence of grooves on the major chela, length of the stylocerite, shape of the median cleft on the posterior margin of telson etc, cf. Banner and Banner 1981: 62–63, fig. 7a–g), and placed both *S. latirostris* and *S. sibogae* in the synonymy of *S. serratidigitus*. Thus *S. serratidigitus* is currently interpreted as a morphologically highly variable species, widely distributed in the Indo-Pacific from the Red Sea to the Gulf of California.

However, reporting *S. sibogae* from north-eastern Australia, Banner and Banner (1982: fig. 94) noted and illustrated important morphological differences in the shape and the armature of major chela, the proportions of carpal articles in the second pereopod and its relative width, between the male and the female specimen. The authors did not know how to evaluate these important differences, but suspected that "they may lie within extremes of variation in Australian populations". In my opinion, the two specimens reported as *S. sibogae* by Banner and Banner (1982) belong to two different species. More than three species are probably involved in the *S. serratidigitus* complex, explaining the morphological variation reported by Banner and Banner (1981). The differences in colour patterns between *S. latirostris* and *S. serratidigitus* are striking (Coutière 1899; Banner and Banner 1981; see also above), and support the discrimination between these two species. Colour patterns are generally constant within the same species, and the slightest differences may indicate the presence of cryptic species (Knowlton and Keller 1985; Knowlton and Mills 1992; Bruce 1987, 1999; Anker 2001). All these findings show that the synonymy of *S. latirostris* and *S. sibogae* with *S. serratidigitus*, as proposed by Banner and Banner (1981), was premature,

and would cause confusion in the future. Therefore, I recommend treating both *S. latirostris* and *S. sibogae* as valid species at present, and will attempt a thorough revision of the *S. serratidigitus* species complex in the future.

The other Indo-Pacific species of *Salmoneus* with simple conical (i. e. not extremely slender and elongate) dactyli on the third to fifth pereopods, and without carinae on the carapace, can be separated from *S. aff. serratidigitus* by the combination of several features, including the length and the shape of the rostrum, the shape of the orbital teeth, the length of the stylocerite, and the shape of the posterior cleft on the telson (e.g., De Man 1915; Edmondson 1930; Miya 1972).

DISCUSSION

The alpheid fauna of Australia has been studied by Banner and Banner (1973, 1975, 1982, 1986), Bruce (1983, 1988a, 1988b, 1988c, 1991, 1993, 1994a, 1994b) and Bruce and Coombes (1997). Davie (2002) compiled information on the taxonomy and distribution of all 159 species and subspecies of Australian Alpheidae, many of which are actually species complexes in need of revision (pers. obs.). The present study adds two more species to the list of Australian alpheid shrimps, *Salmoneus cristatus* and *S. seticheles*.

Salmoneus seticheles from the Northern Territory is remarkable within *Salmoneus* in having a dimorphic smaller cheliped. This unique dimorphism is different from the sexual dimorphism of the chelipeds in many species of *Alpheus*, where male and female chelipeds are of similar size (e.g., Banner and Banner 1982). On the other hand, complexly polymorphic or sexually dimorphic chelipeds are known in many species of *Athaus*, e.g., *A. diuorplus* Ortmann, 1890, *A. phyllocheles* Banner and Banner, 1983, *A. polymorphus* Kemp, 1915, and *A. japonicus* Kubo, 1936 (e.g., Coutière 1899; Kemp 1915; Miya and Miyake 1968; Banner and Banner 1973, 1983; Anker, in press). The long, flexible setae, fringing the lower and the upper chela margins in the major and the subminor chelipeds, is another species-specific feature of *S. seticheles*. These setae are possibly used for filtering out food particles and/or for burrow sweeping.

The specific identity of the incomplete specimen from Queensland, here reported as *S. sp. aff. serratidigitus*, remains uncertain. The identification of this species will require collection of intact specimens. The morphologically variable *S. serratidigitus s. lat.* (*sensu* Banner and Banner 1981) is most probably a species complex, which also contains *S. latirostris* and *S. sibogae*. After having been placed in synonymy of *S. serratidigitus* by Banner and Banner (1981), both *S. latirostris* and *S. sibogae* are here treated as distinct species. The resurrection of these species appears

necessary to avoid further confusion. The taxonomic identity of *S. serratidigitus* is now restricted to the description and figures by Coutière (1896, 1899) and the description and figures of the neotype by Banner and Banner (1981). The revision of the *S. serratidigitus* complex is necessary, but would require recollection of specimens of *S. latirostris* and *S. sibogae* from the type localities (Red Sea, Djibouti, Banda Sea), and examination of numerous other specimens identified as *S. serratidigitus* from the Indo-Pacific, which is beyond the scope of this study.

Noteworthy, two other species of *Salmoneus* were originally described as morphologically variable. The holotype of the western Atlantic *S. cavicolus* Felder and Manning, 1986, an ovigerous female, differs in at several important features from the two "male" paratypes (cf. Felder and Manning 1986: fig. 4b and 4g, 4j, fig. 6e). These differences are clearly not intraspecific, and I believe that at least two different species have been described under the name "*S. cavicolus*" (Anker, in prep.). *Salmoneus sketi* Fransen, 1991, known from two ovigerous females collected in the same marine cave in the Adriatic Sea, is also variable in several features (cf. Fransen 1991: figs 1, 2, 16, 26, 27, 28), which, however,

are less conspicuous and could be intraspecific.

Banner and Banner (1981: 52–54) provided a key to 14 species of *Salmoneus*. This key did not include *S. latirostris* and *S. sibogae*. Since 1981 eight additional species have been described in this genus, including *S. seticheles*. Therefore, a new key appears to be necessary. The updated key below includes all valid species of *Salmoneus*, and also *S. latirostris* and *S. sibogae*. However, the use of this key implies that the specimens are intact and have both chelipeds, or at least the major cheliped. The identification of incomplete specimens of *Salmoneus*, e.g., those lacking the major cheliped, is always tentative, even for species having other distinguishing features. The major cheliped is unknown in two species of *Salmoneus* (*S. tafaongae* Banner and Banner, 1966 and *S. hilarulus* (De Man, 1910)). The position of these species in the present key is tentative, and based on the assumption that the chelipeds of *S. tafaongae* would be similar to those of the presumably related *S. rostratus*, whereas the chelipeds of *S. hilarulus* would be similar to those of the possibly closely related *S. serratidigitus*. In Banner and Banner's (1981) key the position of *S. tafaongae* and *S. hilarulus* is not dependent on cheliped features.

Key to world species of *Salmoneus*

Abbreviations used in the key: IWP, Indo-West Pacific; WP, Western Pacific; EP, Eastern Pacific; CP, Central Pacific; IP, Indo-Pacific; WA, Western Atlantic; EA, Eastern Atlantic; CA, Central Atlantic; IO, Indian Ocean.

- 1a. Major chela without long, flexible setae fringing upper and lower margin of distal palm and fingers 2
- 1b. Major chela with long, flexible setae fringing upper and lower margin of palm and fingers; smaller cheliped polymorphic: (1) minor cheliped – much smaller and less robust than major cheliped, without long flexible setae, with chela not enlarged and unarmed, (2) subminor cheliped – subequal to major cheliped, with long flexible setae, with chela enlarged and armed with large teeth; eyes visible in dorsal and lateral view; rostrum with subapical inferior tooth (IO: Northern Territory, Australia) *S. seticheles* sp. nov.
- 2a. Chelipeds very unequal in size and asymmetrical in shape; minor cheliped much smaller and less robust than major cheliped; minor chela not especially enlarged or elongate, simple, unarmed 6
- 2b. Chelipeds subequal in size, asymmetrical or subsymmetrical in shape; minor (slender) cheliped subequal or longer than major (robust) cheliped; minor chela enlarged or elongate, armed or unarmed (EA) 3
- 3a. Fingers of major chela without teeth; carapace with strong dorsal carina extending from rostrum to anterior third of carapace (EA: Nigeria) *S. jarli* (Holthuis, 1951)
- 3b. Fingers of major chela armed with teeth; carapace with slight carina not extending to anterior third of carapace, or without carina 4
- 4a. Carpus of major and minor cheliped with strong, acute, ventral tooth; posterior margin of telson with small median notch; stylocerite not reaching distal third of second article of antennular peduncle (EA: Cape Verde)
..... *S. caboverdensis* Dworschak, Anker and Abed-Navandi, 2000
- 4b. Carpus of major and minor cheliped without acute, ventral tooth; posterior margin of telson truncate 5

- 5a. Rostrum exceeding distal margin of second article of antennular peduncle; telson slender; minor (slender) cheliped with merus six times as long as wide, and carpus subcylindrical (EA: Adriatic Sea) *S. sketi* Fransen, 1991
- 5b. Rostrum not reaching middle of second article of antennular peduncle; telson relatively broad; minor (slender) cheliped with merus four times as long as wide, and carpus vase-shaped, distally widening (EA: Adriatic Sea)
..... *S. erasimorum* Dworschak, Anker and Abed-Navandi, 2000
- 6a. Merus and propodus of major cheliped deeply excavated; posterior margin of telson truncate, without median notch (WA: Bermuda to Brazil, EP: Gulf of California).....
..... *S. ortmanni* (Rankin, 1898)
- 6b. Merus and propodus of major cheliped not excavated 7
- 7a. Fingers of major chela serrated with small teeth along entire cutting margin, except for tips and sometimes distal 1/4 10
- 7b. Fingers of major chela serrated with larger teeth along proximal 1/2 or 1/3 of cutting margin; eyes visible in dorsal and lateral view 8
- 8a. Rostrum not reaching distal margin of first article of antennular peduncle, without subapical tooth on ventral margin; post-rostral tubercle absent; eyestalk without antero-median tubercle (WP: Gulf of Thailand) *S. bruni* Banner and Banner, 1966
- 8b. Rostrum exceeding distal margin of first article of antennular peduncle, with subapical tooth on ventral margin 9
- 9a. Post-rostral tubercle present; rostrum not reaching third article of antennular peduncle; extra-corneal teeth not upturned; eyestalk with small antero-median tubercle (IWP: Madagascar, Thailand, Papua New Guinea) *S. rostratus* Barnard, 1962
- 9b. Post-rostral tubercle absent; rostrum reaching almost to distal margin of antennular peduncle; extra-corneal teeth upturned; large cheliped unknown (WP: Samoa)
.....*S. tafaongae* Banner and Banner, 1966
- 10a. Fingers of major chela with proximal teeth much larger than distal teeth; rostrum exceeding distal margin of first article of antennular peduncle; eyestalk with antero-median tubercle; carapocerite robust, reaching distal margin of scaphocerite blade (WP: Singapore)
.....*S. singaporensis* Anker, in press
- 10b. Fingers of major chela with proximal teeth subequal to distal teeth 11
- 11a. Carapace densely covered with conspicuous, coarse setae; rostrum exceeding distal margin of second article of antennular peduncle; extra-corneal teeth large, triangular; space between rostrum and extra-corneal teeth broadly U-shaped; telson with shallow, triangular median notch; stylocerite reaching far beyond distal margin of second article of antennular peduncle (CA: Ascension I., WA: NE Brazil) *S. setosus* Manning and Chace, 1990
- 11b. Carapace without setae, or covered with rather inconspicuous, thin setae 12
- 12a. Carapace with ridges or crests arising in orbital area and running parallel or subparallel to median crest 13
- 12b. Carapace without ridges or crests 15
- 13a. Lateral crests of carapace arising from lateral edges of rostrum, medial to extra-corneal teeth, extending only slightly behind eyes; posterior margin of telson with shallow triangular notch; major chela with distal 1/4 of fingers unarmed; rostrum as long as broad at base; extra-corneal teeth acute, directed somewhat mesially; colour pattern: transversely banded with bright red (IWP: Red Sea to Australia)..... *S. cristatus* (Coutière, 1897)
- 13b. Lateral crests or carinae of carapace arising from extra-corneal teeth; posterior margin of telson with deep, U-shaped notch; distal 1/4 of fingers of major chela with teeth 14

- 14a. Lateral crests of carapace conspicuous, running parallel to median crest and reaching beyond middle of carapace; rostrum greater in length than basal width, reaching beyond distal margin of second article of antennular peduncle; extra-corneal teeth slender, directed somewhat mesially; colour pattern: semi-transparent, with red chromatophores on posterior abdominal somites and posterior carapace (IWP: E Africa to Polynesia) *S. triceristatus* Banner, 1959
- 14b. Lateral carinae of carapace rather inconspicuous, running obliquely towards median crest, reaching slightly beyond eyes; rostrum equivalent in length to basal width, short, reaching to distal margin of first article of antennular peduncle, not much lower than dorso-median carina in lateral view; extra-corneal teeth broadly triangular, directed slightly laterally (IWP: Red Sea to Hawaii) *S. brevirostris* (Edmondson, 1930)
- 15a. Posterior margin of telson truncate, without median notch (WA) 16
- 15b. Posterior margin of telson with median notch 17
- 16a. Rostrum much greater in length than basal width; eyes visible in dorsal view; carapace without small pits; dactylus of third to fifth pereopods long and slender; second article of antennular peduncle longer than first (WA: Florida) *S. cavicolus* Felder and Manning, 1986
- 16b. Rostrum much broader at base than long; eyes not visible in dorsal view; carapace with small pits; dactylus of third to fifth pereopods not particularly slender; second article of antennular peduncle as long as first (WA: Caribbean Sea; NE Brazil) *S. arubae* (Schmitt, 1936)
- 17a. Dactylus of major chela reaching far beyond pollex, strongly hooked; carapace inflated; rostrum lower than carapace in lateral view; dactylus short, stout; posterior margin of telson with broad U-shaped notch (WP: S. Japan) *S. babai* Miya and Miyake, 1966
- 17b. Dactylus of major chela subequal to pollex, moderately curved 18
- 18a. Dactylus of third pereopod very slender, elongate, 6–10 times as long as broad at base, about half length of propodus; rostrum much longer than broad at base, with small subapical tooth on ventral margin; eyes partly visible in dorsal and lateral view (WP: S Japan to Micronesia) *S. gracillipes* Miya, 1972
- 18b. Dactylus of third pereopod about 3–5 times as long as broad at base, about 1/3 length of propodus 19
- 19a. Major chela with cutting margin of fingers bearing not more than seven teeth; posterior margin of telson with broad triangular cleft (CP: Hawaii) *S. mauiensis* (Edmondson, 1930)
- 19b. Major chela with cutting margin of fingers bearing at least eight teeth 20
- 20a. Rostrum as long as broad at base, lateral margins distally slightly convex 21
- 20b. Rostrum longer than broad at base, lateral margins not convex 22
- 21a. Most anterior portion of eyes visible in dorsal view; posterior margin of telson with deep median notch; second pereopod with ischium bearing one spine; colour pattern: transversely banded with bright red (IO: Red Sea, Gulf of Aden) *S. latirostris* (Coutière, 1896)
- 21b. Eyes not visible in dorsal view; posterior margin of telson with small, shallow median notch; carapace with small pits; second pereopod with ischium unarmed (CA: Ascension Island, WA: Caribbean Sea) *S. teres* Manning and Chace, 1990
- 22a. Stylocerite not reaching distal margin of second article of antennular peduncle; distal 2/3 of rostrum very slender; telson with both pairs of dorsal spines situated in posterior third; large cheliped unknown (WP: Indonesia) *S. hilarulus* (De Man, 1910)
- 22b. Stylocerite overreaching distal margin of second article of antennular peduncle; at most distal 1/3 of rostrum slender 23
- 23a. Third pereopods with ischium bearing two or three spines, and with propodus bearing three to six spines on inferior margin; posterior margin of telson with U-shaped notch and two to four pairs of setae (IP: Red Sea to Gulf of California) *S. serratidigitus* (Coutière, 1896)
- 23b. Third pereopods with ischium bearing one spine, and with propodus bearing two spines on inferior margin; posterior margin of telson with trapeziform notch and one pair of setae (IWP: Red Sea to Australia) *S. sibogae* (De Man, 1910)

Several species of *Salmoneus* appear to be undescribed. One of them has been collected in the eastern Mediterranean Sea (Grippa 2002); it appears to be closely related to the Indo-Pacific *S. serratidigitus*, and would be the first member of the *S. serratidigitus* species group in the eastern Atlantic. At least three undescribed species of *Salmoneus* are known from the Western Atlantic (Anker, in prep.). The first is sympatric with the closely related *S. cavicolus*, presently known only from the type locality in the Indian River estuary in Florida. The second was recently collected in the Atol das Rocas off north-eastern Brazil, and appears to be closest to *S. arubae* and *S. teres*. Schmitt's (1924) record of "*Jousseanmea trigona* Rathbun 1901" (now *Alpheopsis trigonus* (Rathbun)) from Barbados is based on an incomplete specimen of *Salmoneus*, possibly a new species close to the Indo-west Pacific *S. tricristatus* (Anker, pers. obs.). All these undescribed species and the poor taxonomic status of several described species (e.g., *S. serratidigitus*, *S. cavicolus*, *S. tafaongae*) shows that the genus *Salmoneus* clearly needs further taxonomic and phylogenetic work.

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